Influence of Plasma Instabilities on the Emittance of the Extracted Ion Beam

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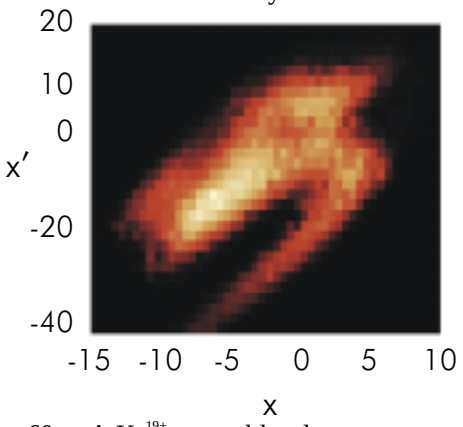
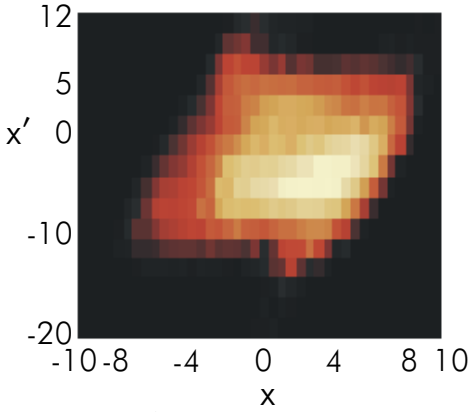
Systematic ion beam emittance measurements in both the horizontal (xx') and vertical plane (yy') were performed for a wide range of ions. For a particular ion beam, an important contribution to the emittance was the plasma stability. Surprisingly, the emittance values were approximately independent of the current at low and medium ion beam intensities. For instance Ar^{9+} normalized rms emittance values were measured to be .067, 0.064, 0.065, 0.058 π·mm·mrad at total extracted currents of 0.75, 0.86, 1.2 and 2 emA, delivering 10, 52, 108 and 145 euA of Ar^{9+} at 15 kV extraction voltages. The emittance values changed less than 10% over the mentioned intensity range, the lowest emittance was actually measured at the highest current in this case. On the other hand, the ion beam emittance can easily change a factor of 2 or 3 at comparable ion beam intensity for unstable plasma conditions. Fig. 1 shows an example of two different ion source tunes of $^{86}Kr^{19+}$ at comparable currents and power levels (please note the different scales in the x and x' axis). The influence of the plasma stability on the ion beam emittance can be clearly seen. The Faraday Cup readings for both tunes are similar, only the emittance measurement indicates the presence of plasma instabilities.

The plasma condition and stability are strongly influenced by the plasma chamber wall condition. If the source had been opened or the ion beam had been changed from one metal to another, it can take 2 to 3 days before the lowest emittance values and peak performance can be achieved. Consequently during rapid beam changes involving high intensity metal ion beams, the tune has to be balanced between maximum intensity and beam quality.

The emittance measurement is then used as an online ion source tuning aid and is an important step in our goal to improve the overall ion beam transmission into the cyclotron.



60 eμA Kr^{19+}, unstable plasma,
ε_{norm}=0.09 π·mm·mrad
x axis: –15 to 10 mm, x' axis: -40 to 20 mrad



50 eμA Kr^{19+}, stable plasma,
ε_{norm}=0.03 π·mm·mrad
x axis: –10 to 10 mm, x' axis: -20 to 12 mrad

Fig. 1. Measured emittances for two different ion source tunes for high intensity Kr^{19+} beams.

Footnotes and References

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